Some Insights into Properties and Processes with Balance Equations for Mass, Energy, and Entropy

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ABSTRACT

Balance equations expressing the First and Second Laws of Thermodynamics yield rigorous connections among heat, work, and material flows, as well as properties of the streams in proposed or existing processes. These are reliable when property models provide accurate values for the conceptual properties of enthalpy and entropy in terms of measurable properties, such as temperature, pressure, and composition. The approach is to establish a process configuration with two unspecified material or energy flows or properties and then find their values via the balance equations.

Different kinds of analyses can be done. One is to determine a constraint on one stream and the irreversibility, *i.e.*, entropy generation, of a real or proposed process. Another is to determine two required conditions of a process from a specified amount of entropy generation. In particular, a specification of reversibility, *i.e.*, zero entropy generation, gives the conditions for maximum efficiency such as minimum heat rejected and work input. In either case, the results can be used to focus on locations and impacts of entropy generation in order to suggest efficiency improvements. An additional analysis can check the accuracy of property models for processes with multiple sections by comparing the sum of surroundings energy flows and entropy productions of individual sections with results from analyzing the whole system.

Applications made so far have considered possible reversible processes, found entropy generation for known processes or from process simulation software, shown inconsistencies in property models for complex chemical systems, yielded comparisons of energy effects using different property models, and demonstrated process sensitivities to entropy generation values.

The lecture will summarize the fundamental equations, illustrate several cases from simple to complex process systems, and suggest extensions.